What is claimed is:

1. An optical pickup apparatus to conduct reproducing and/or recording information of a first optical information recording medium including a first transparent base plate having a thickness of t1 and a second optical information recording medium including a second transparent base plate having a thickness of t2 ($t2>t1$), comprising:

a first light source to emit a first light flux having a wavelength of $\lambda 1$;

a second light source to emit a second light flux having a wavelength of $\lambda 2$ ($\lambda 1 < \lambda 2$);

a converging optical system to converge the first light flux or the second light flux onto a first information recording surface of the first optical information recording medium or a second information recording surface of the second optical information recording medium, the converging optical system having an objective lens; and

an optical detector to receive reflected light from the first optical information recording medium or the second optical information recording medium;

wherein the converging optical system comprises a diffracting section on an entire surface in an effective

2. The optical pickup apparatus of claim 1, wherein the following formula is satisfied:

$m = n$.

3. The optical pickup apparatus of claim 1, wherein when an optical path difference function of the diffracting surface is $\phi(h)$ where h is a distance from the optical axis along the direction perpendicular to the optical axis at the surface provided with the diffracting section, $d\phi(h)/dh$ is discontinuous or substantially discontinuous at least one point, whereby the spherical aberration has at least one discontinuous portion or at least one substantially discontinuous portion when the converging optical system converges the second light flux onto the second information recording surface so as to conduct reproducing and/or recording the information of the second optical information recording medium.

4. The optical pickup apparatus of claim 3, wherein the diffracting section has plural diffracting ring-shaped bands in which a prescribed ring-shaped band is located at the outermost side among inner ring-shaped bands located on an inside of the point of h where $d\phi(h)/dh$ is discontinuous or

substantially discontinuous and a neighbor ring-shaped band neighbors the prescribed ring-shaped band and is located on an outside of the point of h and, and wherein a width of the prescribed ring-shaped band along a direction perpendicular to an optical axis of the surface having the diffracting section is smaller than that of the neighbor ring-shaped band.

5. The optical pickup apparatus of claim 1, wherein a necessary numerical aperture at an optical information recording medium-side of the converging optical system necessary to conduct recording or reproducing the information of the first optical information recording medium with the first light flux is NA1 and a necessary numerical aperture at an optical information recording medium-side of the converging optical system necessary to conduct recording or reproducing the information of the second optical information recording medium with the second light flux is NA2 (NA1 > NA2), and wherein among the second light flux having passed the objective lens, a light flux having passed a portion of the objective lens whose numerical aperture at the optical information recording media-side is not smaller than NA2 and is not larger than NA1 forms a spot on the second information recording surface through the second transparent base plate

of the second optical information recording medium, a diameter of the spot is not smaller than w2 and is not larger than w1, and the following conditional formulas are satisfied:

$$10\ \mu m \leq w2 \leq 50\ \mu m.$$

$$20\ \mu m \leq w1 - w2 \leq 110\ \mu m.$$

6. The optical pickup apparatus of claim 1, wherein when the diffracting section is provided on an aspheric surface of the objective lens and a length x along an optical axis of the objective lens is x coordinate and a height h perpendicular to the optical axis is h coordinate, dx/dh is discontinuous or substantially discontinuous at at least one point on a basic aspheric surface of the aspheric surface provided with the diffracting section, whereby the spherical aberration has at least one discontinuous portion or at least one substantially discontinuous portion when the converging optical system converges the second light flux onto the second information recording surface so as to conduct reproducing and/or recording the information of the second optical information recording medium.

7. The optical pickup apparatus of claim 1, wherein the diffracting section is provided on a surface of the objective

lens and the objective lens has a stepped portion in an effective aperture.

8. The optical pickup apparatus of claim 1, wherein a necessary numerical aperture at an optical information recording medium-side of the converging optical system necessary to conduct recording or reproducing the information of the first optical information recording medium with the first light flux is NA1 and a necessary numerical aperture at an optical information recording medium-side of the converging optical system necessary to conduct recording or reproducing the information of the second optical information recording medium with the second light flux is NA2 (NA1 > NA2), and wherein among the first light flux having passed the objective lens, when a first light flux having passed a portion of the objective lens whose numerical aperture at the optical information recording media-side is not larger than NA1 passes through the first transparent base plate of the first optical information recording medium, a wave front aberration of the first light flux on the first information recording surface is not larger than 0.07λ1 rms, and among the second light flux having passed the objective lens, when a second light flux having passed a portion of the objective lens whose numerical aperture at the optical information

recording media-side is not larger than NA2 passes through the second transparent base plate of the second optical information recording medium, a wave front aberration of the second light flux on the second information recording surface is not larger than 0.07λ2 rms.

9. The optical pickup apparatus of claim 8, wherein among the second light flux having passed the objective lens, when the second light flux having passed a portion of the objective lens whose numerical aperture at the optical information recording media-side is not larger than NA2 passes through the second transparent base plate of the second optical information recording medium, a third-order spherical aberration component of the wave front aberration of the second light flux on the second information recording surface shows an over characteristic and an absolute value (WSA2 · λ2 rms) of the third-order spherical aberration component satisfies the following conditional formula:

$$0.02\lambda 2 \text{ rms} \leq WSA2 \cdot \lambda 2 \text{ rms} \leq 0.06\lambda 2 \text{ rms}.$$

10. The optical pickup apparatus of claim 8, wherein among the first light flux having passed the objective lens, when the first light flux having passed a portion of the objective

lens whose numerical aperture at the optical information recording media-side is not larger than NA1 passes through the first transparent base plate of the first optical information recording medium, an absolute value (WSA1 · λ1 rms) of a third-order spherical aberration component of the wave front aberration of the first light flux on the first information recording surface satisfies the following conditional formula:

$$WSA1 \cdot \lambda 1 \text{ rms} \leq 0.04\lambda 1 \text{ rms}.$$

11. The optical pickup apparatus of claim 1, wherein the spherical aberration has two or more discontinuous portions or two or more substantially discontinuous portions when the converging optical system converges the second light flux onto the second information recording surface so as to conduct reproducing and/or recording the information of the second optical information recording medium.

12. The optical pickup apparatus of claim 1, wherein the objective lens is a single lens having a positive refracting power.

13. The optical pickup apparatus of claim 1, wherein the objective lens comprises a first lens having a positive

refracting power and a second lens having a positive refracting power.

14. The optical pickup apparatus of claim 1, wherein the diffracting section comprises plural diffracting ring-shaped bands among which at least one diffracting ring-shaped band satisfies the following conditional formula:

$$1.2 \leq P_{i+1}/P_i \leq 10$$

where P_i is a width of the diffracting ring-shaped band located at i-th place counted from an optical axis of the surface provided with the diffracting section to a periphery of the objective lens in which the width is along the direction vertical to the optical axis.

15. The optical pickup apparatus of claim 1, wherein a number m of a ring-shaped band through which a light ray of NA of 0.60 passes satisfies the following conditional formula:

$$22 \leq m \leq 32$$

wherein a number of ring-shaped band located on an optical axis on a surface provided with the diffracting section is 1 and the number m is counted toward the periphery side.

16. The optical pickup apparatus of claim 1, wherein a necessary numerical aperture at an optical information recording medium-side of the converging optical system necessary to conduct recording or reproducing the information of the first optical information recording medium with the first light flux is NA1 and a necessary numerical aperture at an optical information recording medium-side of the converging optical system necessary to conduct recording or reproducing the information of the second optical information recording medium with the second light flux is NA2 (NA1 > NA2), and wherein among the first light flux having passed the objective lens, when a first light flux having passed a portion of the objective lens whose numerical aperture at the optical information recording media-side is not larger than NA1 passes through the second transparent base plate of the second optical information recording medium, a wave front aberration of the first light flux on the first information recording surface is not larger than 0.07λ1 rms, and among the second light flux having passed the objective lens, when a partial second light flux having passed a portion of the objective lens whose numerical aperture at the optical information recording media-side is not larger than NA2 passes through the second transparent base plate of the second optical information recording medium, a wave front

aberration of the partial second light flux on the second information recording surface is not larger than $0.07\lambda2$ rms, and when another partial second light flux having passed a portion of the objective lens whose numerical aperture at the optical information recording media-side is larger than NA2 passes through the second transparent base plate of the second optical information recording medium, a wave front aberration of the another partial second light flux on the second information recording surface is larger than $0.07\lambda2$ rms.

17. The optical pickup apparatus of claim 1, wherein a numerical aperture of NAZ is a predetermined value which satisfies the following conditional formula:

$0.43 \leq NAZ \leq 0.53$, and

wherein among the second light flux having passed the objective lens, when a partial second light flux having passed a portion of the objective lens whose numerical aperture at the optical information recording media-side is not smaller than NAZ and not larger than 0.7 passes through the second transparent base plate of the second optical information recording medium and when another partial second light flux having passed a portion of the objective lens

whose numerical aperture at the optical information recording media-side is smaller than NAZ passes through the second transparent base plate of the second optical information recording medium, an amount of spherical aberration of the partial second light flux is larger by 10λ2 or more than that of the another partial second light flux.

18. The optical pickup apparatus of claim 1, wherein the optical detector comprises a light receiving surface arranged at a predetermined position and a numerical aperture of NAZ is a predetermined value which satisfies the following conditional formula:

$0.43 \leq NAZ \leq 0.53$, and

wherein among the second light flux having passed the objective lens, when a partial second light flux having passed a portion of the objective lens whose numerical aperture at the optical information recording media-side is smaller than NAZ passes through the second transparent base plate of the second optical information recording medium, reflected light of the partial second light flux from the second recording surface proceeds into the light receiving surface of the optical detector and when another partial second light flux having passed a portion of the objective lens whose numerical aperture at the optical information

recording media-side is not smaller than NAZ passes through the second transparent base plate of the second optical information recording medium, reflected light of the another partial second light flux from the second recording surface proceeds into a periphery region other than the light receiving surface of the optical detector.

19. The optical pickup apparatus of claim 1, wherein the optical detector comprises a central light receiving surface and a peripheral light receiving surface arranged at predetermined positions respectively and a numerical aperture of NAZ is a predetermined value which satisfies the following conditional formula:

$0.43 \leq NAZ \leq 0.53$, and

wherein among the second light flux having passed the objective lens, when a partial second light flux having passed a portion of the objective lens whose numerical aperture at the optical information recording media-side is not smaller than NAZ passes through the second transparent base plate of the second optical information recording medium, reflected light of the another partial second light flux from the second recording surface proceeds into the peripheral light receiving surface of the optical detector

other than the central light receiving surface or a periphery region other than the periphery light receiving surface.

20. The optical pickup apparatus of claim 1, wherein the diffracting section comprises a first diffracting section and a second diffracting section and an order number of a strongest diffracted light ray generated by the first diffracting section for a light flux having a predetermined wavelength and an order number of a strongest diffracted light ray generated by the second diffracting section for the light flux having the predetermined wavelength are different from each other and not zero respectively.

21. The optical pickup apparatus of claim 1, wherein the diffracting section comprises a first diffracting section and a second diffracting section and an order number of a strongest diffracted light ray generated by the first diffracting section for a light flux having a predetermined wavelength and an order number of a strongest diffracted light ray generated by the second diffracting section for the light flux having the predetermined wavelength are same to each other and not zero respectively.

24. The objective lens of claim 23, wherein the following formula is satisfied:

$m = n$.

25. The objective lens of claim 23, wherein when an optical path difference function of the diffracting surface is $\phi(h)$ where h is a distance from the optical axis, $d\phi(h)/dh$ is discontinuous or substantially discontinuous at least one point, whereby the spherical aberration has at least one discontinuous portion or at least one substantially discontinuous portion when the converging optical system converges the second light flux onto the second information recording surface so as to conduct reproducing and/or recording the information of the second optical information recording medium.

26. The objective lens of claim 25, wherein the diffracting section has plural diffracting ring-shaped bands in which a prescribed ring-shaped band is located at the outermost side among inner ring-shaped bands located on an inside of the point of h where $d\phi(h)/dh$ is discontinuous or substantially discontinuous and a neighbor ring-shaped band neighbors the prescribed ring-shaped band and is located on an outside of

the point of h and, and wherein a width of the prescribed ring-shaped band along a direction perpendicular to an optical axis of the surface having the diffracting section is smaller than that of the neighbor ring-shaped band.

27. The objective lens of claim 23, wherein when the objective lens has an aspheric surface and a length x along an optical axis of the objective lens is x coordinate and a height h perpendicular to the optical axis is h coordinate, dx/dh is discontinuous or substantially discontinuous at least one point on a basic aspheric surface of the aspheric surface.

28. The objective lens of claim 23, wherein the objective lens has a stepped portion in an effective aperture.

29. The objective lens of claim 23, wherein when the objective lens converges the second light flux onto the second information recording surface in order to conduct reproducing and/or recording the information of the second optical information recording medium, a spherical aberration has at least two discontinuous portion or at least two substantially discontinuous portion.

30. The objective lens of claim 22, wherein the objective lens is a single lens having a positive refracting power.

31. The objective lens of claim 22, wherein the objective lens comprises a first lens having a positive refracting power and a second lens having a positive refracting power.

32. The objective lens of claim 22, wherein the diffracting section comprises plural diffracting ring-shaped bands among which at least one diffracting ring-shaped band satisfies the following conditional formula:

$$1.2 \leq P_{i+1}/P_i \leq 10$$

where P_i is a width of the diffracting ring-shaped band located at i-th place counted from an optical axis of the surface provided with the diffracting section to a periphery of the objective lens in which the width is along the direction perpendicular to the optical axis.

33. The objective lens of claim 22, wherein a number m of a ring-shaped band through which a light ray of NA of 0.60 passes satisfies the following conditional formula:

$$22 \leq m \leq 32$$

wherein a number of ring-shaped band located on an optical axis on a surface provided with the diffracting section is 1 and the number m is counted toward the periphery side.

34. The objective lens of claim 22, wherein the diffracting section comprises a first diffracting section and a second diffracting section and an order number of a strongest diffracted light ray generated by the first diffracting section and an order number of a strongest diffracted light ray generated by the second diffracting section for a light flux having a predetermined wavelength are different from each other and not zero respectively.

35. The objective lens of claim 22, wherein the diffracting section comprises a first diffracting section and a second diffracting section and an order number of a strongest diffracted light ray generated by the first diffracting section and an order number of a strongest diffracted light ray generated by the second diffracting section for a light flux having a predetermined wavelength are same to each other and not zero respectively.

36. An optical information reproducing and/or recording apparatus to conduct reproducing and/or recording information

aperture or an almost entire surface in the effective aperture of at least one surface thereof,

the converging optical system generates a m-th order diffracted light ray (m being an integer other than zero) more than other order diffracted light rays when the first light flux passes the diffracting section and converges the m-th order diffracted light ray onto the first information recording surface so as to conduct the reproducing and/or recording information of the first optical information recording medium;

the converging optical system generates a n-th order diffracted light ray (n being an integer other than zero) more than other order diffracted light rays when the second light flux passes the diffracting section and converges the n-th order diffracted light ray onto the second information recording surface so as to conduct the reproducing and/or recording information of the second optical information recording medium; and

a spherical aberration has at least one discontinuous portion or at least one substantially discontinuous portion when the converging optical system converges the second light flux onto the second information recording surface so as to conduct reproducing and/or recording the information of the second optical information recording medium.

22. An objective lens for use in an optical pickup apparatus to conduct reproducing and/or recording information of an optical information recording medium having a transparent base plate, comprising:

at least one surface;

wherein a diffracting section is provided on an entire surface of an effective aperture of the surface or an almost entire surface of the effective aperture of the surface, wherein when a light flux having a predetermined wavelength passes the diffracting section, the objective lens generate a m-th order diffracted light ray (m being an integer other than zero) more than other order light rays and when the m-th order diffracted light ray is converged through a transparent base plate having a predetermined thickness, a spherical aberration has at least one discontinuous portion or at least one substantially discontinuous portion.

23. The objective lens of claim 21, wherein the optical pickup apparatus conducts reproducing and/or recording information of a first optical information recording medium including a first transparent base plate having a thickness of t1 and a second optical information recording medium including a second transparent base plate having a thickness of t2 (t2>t1),

when a first light flux having a wavelength of $\lambda 1$ passes the diffracting section, the objective lens generates the m-th order diffracted light ray (m being an integer other than zero) more than other order diffracted light rays and converges the m-th order diffracted light rays onto a first information recording surface so that the optical pickup apparatus conducts the reproducing and/or recording information of the first optical information recording medium;

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when a second light flux having a wavelength of $\lambda 2$ ($\lambda 1 < \lambda 2$) passes the diffracting section, the objective lens generates the n-th order diffracted light ray (n being an integer other than zero) more than other order diffracted light rays and converges the n-th order diffracted light rays onto a second information recording surface so that the optical pickup apparatus conducts the reproducing and/or recording information of the second optical information recording medium; and

when the objective lens converges the second light flux onto the second information recording surface, a spherical aberration has at least one discontinuous portion or at least one substantially discontinuous portion.

of a first optical information recording medium including a first transparent base plate having a thickness of t1 and a second optical information recording medium including a second transparent base plate having a thickness of t2 (t2>t1), comprising:

an optical pickup apparatus comprising:

a first light source to emit a first light flux having a wavelength of $\lambda1$;

a second light source to emit a second light flux having a wavelength of $\lambda2$ ($\lambda1 < \lambda2$);

a converging optical system to converge the first light or the second light flux onto a first information recording surface of the first optical information recording medium or a second information recording surface of the second optical information recording medium, the converging optical system having an objective lens; and

an optical detector to receive reflected light from the first optical information recording medium or the second optical information recording medium;

wherein the converging optical system comprises a diffracting section on an entire surface in an effective aperture or an almost entire surface in the effective aperture of at least one surface thereof,

Sub B3

the converging optical system generates a m-th order diffracted light ray (m being an integer other than zero) more than other order diffracted light rays when the first light flux passes the diffracting section and converges the m-th diffracted light ray onto the first information recording surface so as to conduct the reproducing and/or recording information of the first optical information recording medium;

the converging optical system generates a n-th order diffracted light ray (n being an integer other than zero) more than other order diffracted light rays when the second light flux passes the diffracting section and converges the n-th diffracted light ray onto the second information recording surface so as to conduct the reproducing and/or recording information of the second optical information recording medium; and

a spherical aberration has at least one discontinuous portion or at least one substantially discontinuous portion when the converging optical system converges the second light flux onto the second information recording surface so as to conduct reproducing and/or recording the information of the second optical information recording medium.